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CONVERGENT SPRAY PROCESS FOR ENVIRONMENTALLY FRIENDLY COATINGS

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ABSTRACT

Conventional spray application processes have poor transfer efficiencies, resulting in an exorbitant loss in materials, solvents, and time. Also, with ever tightening Environmental Protection Agency (EPA) regulations and Occupational Safety and Health Administration requirements, the low transfer efficiencies have a significant impact on the quantities of materials and solvents that are released into the environment. High solids spray processes are also limited by material viscosities, thus requiring many passes over the surface to achieve a thickness in the 0.125 -inch range. This results in high application costs and a negative impact on the environment.

Until recently, requirements for a 100% solid sprayable, environmentally friendly, lightweight thermal protection system that can be applied in a thick (>0.125 inch) single-pass operation exceeded the capability of existing systems. Such coatings must be applied by hand lay-up techniques, especially for thermal and/or fire protection systems.

The current formulation of these coatings has presented many problems such as worker safety, environmental hazards, waste, high cost, and application constraints. A system which can apply coatings without using hazardous materials would alleviate many of these problems.

Potential applications include the aerospace thermal protective specialty coatings, chemical and petroleum industries that require fire-protection coatings that resist impact, chemicals, and weather. These markets can be penetrated by offering customized coatings applied by automated processes that are environmentally friendly.

Introduction

Currently EPA is preparing regulations and gathering studies to meet rules set by the United States Congress in the Clean Air Act Amendments (CAAA) of 1990. EPA is proposing new Control Techniques guidelines (CTG's), developing rules to limit emissions of toxic air pollutants through two programs, National Emission Standards for Hazardous Air Pollutants (NESHAP's) and Hazardous Air Pollutants (HAP's).

Certain low-usage coatings were not addressed in the NESHAP. These coatings are adhesives, sealants, and 30 types of specialty coatings which

represent less than 6 percent of the total HAP emissions from the industry. Also, the EPA data analyses indicate that the maximum achievable control technology (MACT) floor for these coatings would be no control. The EPA is now requesting public comment on the need for a separate CTG providing guidance for the control of these types of coatings.

The overall objectives of the convergent spray project are to develop and demonstrate a convergent spraying process capable of applying a variety of high-solid coatings. Specific objectives are:

- To develop a solventless, zero-content volatile organic compound (VOC) Convergent Spray Technology (CST) to meet proposed EPA regulations
- To increase the transfer efficiencies of high-solids coating formulations, and
- To increase the application thickness per pass while maintaining the surface properties and coating characteristics.
- To address waste minimization through unique processing.

This project focuses on developing a state-of-the-art high-solids formulation and its associated application processes for thermal protection materials, insulative and structural restoration coatings. Work to date has centered on improving process characteristics while reducing costs and associated hazards.

System Design for Environmental Regulations

In order to address environmental issues such as VOC reduction and or elimination, waste minimization a convergent system was designed to meet the challenges of the 1990's for specialty coating applications. The system is designed as a spray on demand application system. Batch processing and associated wastes with pots and material transfer lines has been significantly eliminated along with the associated costs of material wasted due to short sudden equipment failures. Completion of convergent sprays is followed by a purging of the end effector resin mix system with some 200-300 ml of environmentally acceptable solvent after spray application. Resin and solid filler transfer lines are not purged because there is no mixed materials in lines. This reduces process waste to a same minimum, whether application to large or small parts or configuration.

The ergonomic design of the system also allows for efficient use and experimentation. Simple change out of resin materials, fillers with changes in material flows can lead to new coating development and optimizing performance.

On demand design also allows for more complex application techniques which reduce manual or hand close-out of more complex hardware configurations.

Basic Convergent System

The Convergent Spray process is a means by which mixed resins are sprayed and entrained with solid filler materials outside the spray end effector to form a coherent coating material.

The resin system comprises two fluid transfer systems which supply the end effector with the resin polymer components separately maintaining proportional flow.

Two vibratory loss-in-weight units pneumatically feed a steady, measured stream of glass spheres and cork granules to a cyclonic mixer which then feeds the end effector (although solid, the eccospheres and cork flow much like a fluid).

The convergent spray end effector design consists a spray head in which the epoxy components are mixed and atomized, and a larger shroud, in which the glass/cork mixture is injected into an atomized resin air stream. The solids carrying air stream entrains into the atomizing resin spray (Convergence), and the resin/cork/glass sphere mixture is deposited to the substrate.

Mixing of resins does not occur until the very end of process at the resin mixing system at the specially designed end effector.

The resulting spray coatings produces high viscosity coating that can be applied to vertical surfaces without slumping.

Convergent Applications

Thermal Protection for SRB

A two-part room temperature or heat cure epoxy system, was selected as the resin side system material because it is a familiar adhesive used in the solid rocket booster (SRB) thermal protection system, and has excellent mechanical property characteristics. Granular cork and glass microspheres were selected as the dry system materials.

Tests of coatings comprising epoxy clear resin, granular cork, and glass eccospheres showed the best mix is 75 to 80 percent resin and 20 to 25 percent cork and glass eccospheres which results in densities ranging from 30 to 35 lbs/ft³ and flatwise tensile strength generally from 150-250 pounds per square inch. Additional catalyst was shown to be to be an efficient way to speed the cure of the epoxy resin with no adverse effects.

In 1993, a production prototype was fabricated and installed in Marshall Space Flight Center's Productivity Enhancement Laboratory (building 4708) for detailed assessment and evaluation of a USBI IR&D developed thermal protection coating (TPS).

Equipment was specified and procured and facilities modified to accommodate the prototype. Programmable logic controller and host communications programs were developed to control the prototype. Finally, a spray test program was executed to produce test panels and demonstrate the end effector. As a result, in January 94 Marshall Convergent Coating (MCC-1) was selected for final development and qualification for use as a Thermal Protection System on the Solid Rocket Booster (SRB).

In 1993, USBI Materials and Processes designed, fabricated, and tested a more efficient convergent spray end effector. Improvements in the wet resin

spray system were designed and implemented. This new design was tested with great success in USBI's labs and later at MSFC's labs. Coating variation and surface finish were greatly improved. The coatings also performed well in aerodynamic heating tests in the MSFC Improved Hot Gas Facility. Coatings were also applied to small test articles like cable tunnels used on SRB.

It has also been demonstrated that the coatings will adhere to complex geometries such as stringers, risers, and bolt heads protruding from a structure.

Other lower recession formulations are being developed such as a unique polysiloxane/epoxy and epoxy/phenolic formulations which will potentially reduce recession and increase insulation characteristics.

Finally, the EPA toxic characteristic leaching procedure indicates heavy metal concentrations are well below acceptable limits, thus allowing disposal of cured material in a city landfill as non-regulated waste.

Other Potential High Performance Coatings

With the advent of increased processability and selection of a wide variety of polymer resin systems such as epoxies, urethanes, acrylics, and polyesters potentially new high solids coatings for use as structural, architectural and protective coatings can now be pursued. The capability of convergent spray to use a high degree of inexpensive filler loading can reduce cost of coating materials.

Unsaturated polyester resins can be convergently combined with traditional aggregate materials to be used as a low cost polymer concrete for resurfacing of highways and or support structures. Polyesters offer long endurance, skid resistance and short cure times.

Highly flame retardant epoxy based phosphate intumescent coatings have been developed for use in convergent spray systems. Flame retardants were added to achieve an Underwriters Laboratory (UL) rating of V-0.

Convergent Control Systems Development

Development of the convergent spray system for Thermal Protection involved a wet side (resin) and a dry side (granular cork). The feed and control integrity of each side of the materials system is crucial to ensure an accurate spray and mixing of the applied coating.

The On-Demand design of Convergent Spray puts more emphasis on process control in for materials coatings design. It also gives us the understanding and knowledge of really knowing what's occurring in different area's of the process. It allows the user to take a step back, look at the big picture and divide the process out into modules. In this way the control system can be designed from the top down and implemented and tested from the bottom up allowing us to meet the operational requirements from total quality management.(TQM)

Object oriented control systems and program logic control software (PLC) systems are being used on convergent spray systems. These control systems integrate data acquisition, supervisory control and management information functions and creates a single graphic window into the whole

process. In addition these systems perform alarming, trending and event detection. (See Figure 2)

A portable cart system is in design to address application of structural and architectural coatings. This system is being designed for field application of less critical coatings without the major cost involved with software control and PLC design.

Summary

A demonstration of a new convergent spray process that eliminates volatile, environmentally hazardous solvents has now been demonstrated and has been selected as the next process to be used on the solid rocket booster (SRB) for application of Thermal Protection Coatings.

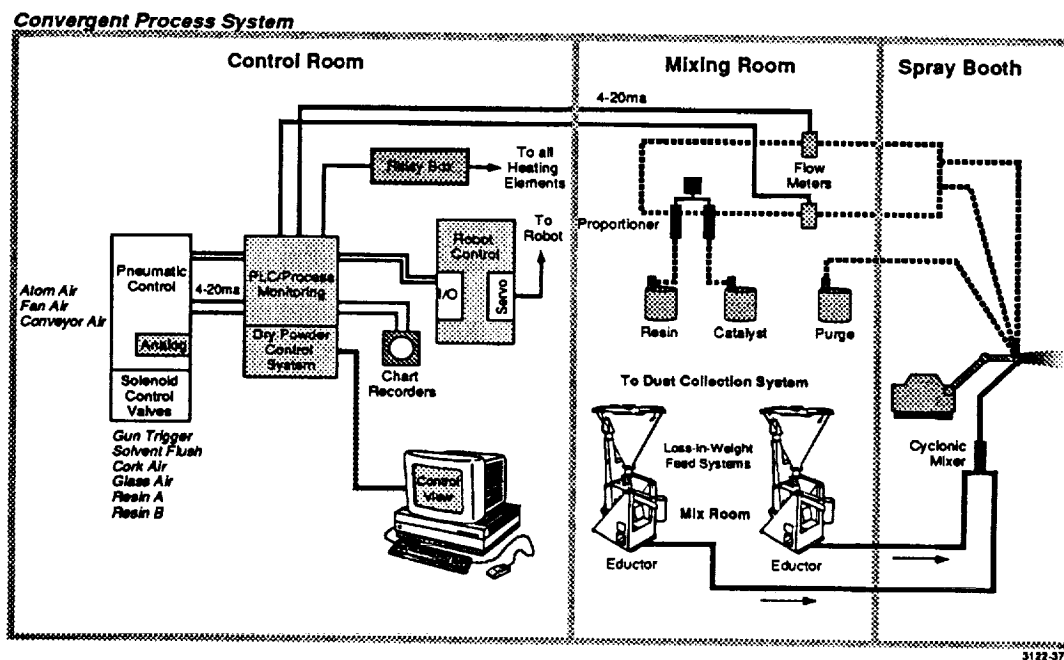


Figure 1: Schematic of solventless spray system. (3122-37)

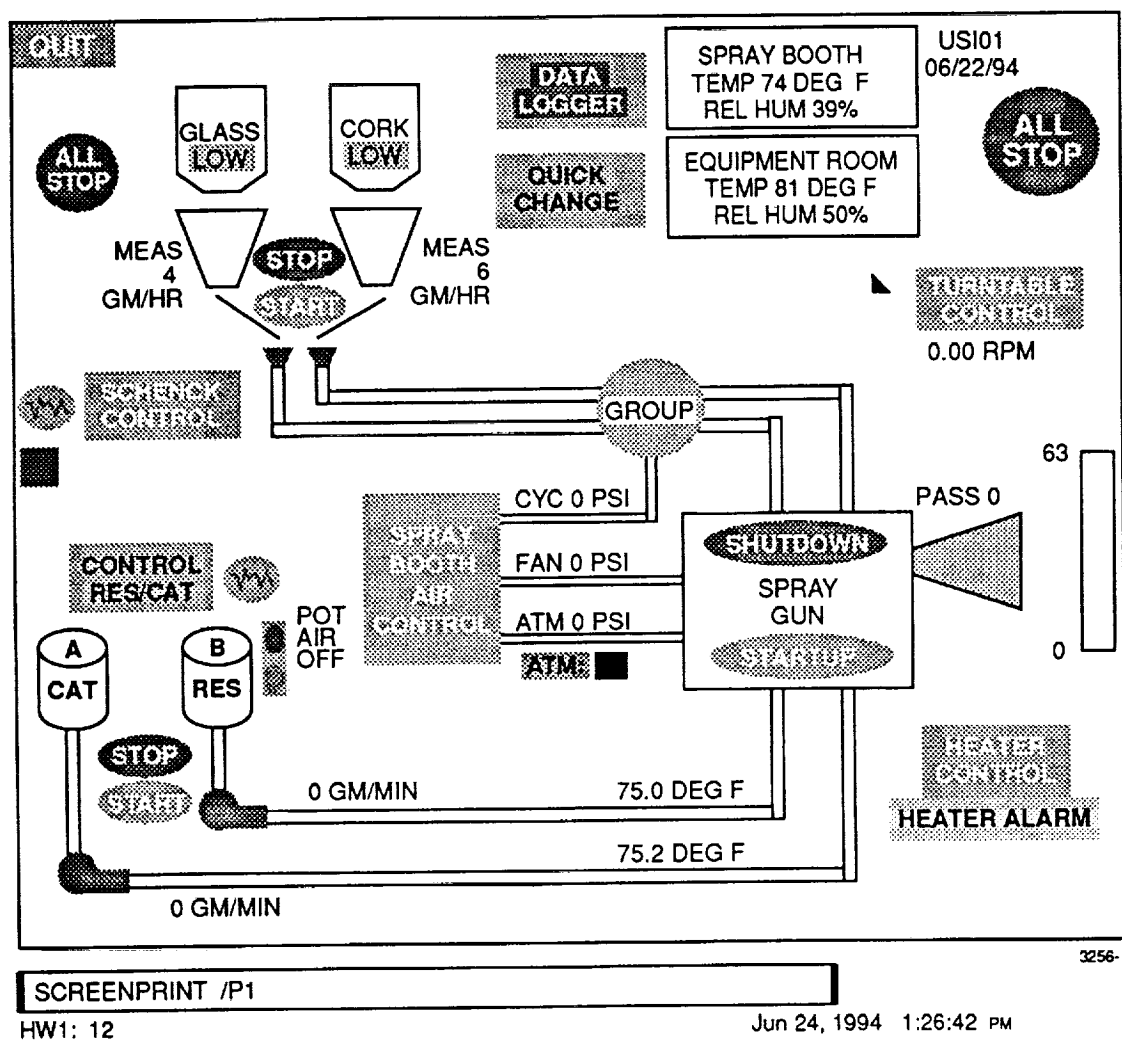


Figure 2 : Software Window Graphic Display

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